

REMARKS

In view of the above amendments and the following remarks, reconsideration of the rejections contained in the Office Action of March 24, 2009 is respectfully requested.

By this Amendment, claims 1, 5 and 8-10 have been amended. Thus, claims 1, 4, 5 and 8-10 are currently pending in the application. No new matter has been added by these amendments.

On pages 3-6 of the Office Action, the Examiner rejected claims 1, 4, 5 and 8 under 35 U.S.C. § 103(a) as being unpatentable over Borsboom et al. (US 4,981,661) in view of Forg et al. (US 5,660,807), Kettner et al. (US 4,857,297) and Messenger (WO 02/04389). On pages 7-10 of the Office Action, the Examiner rejected claims 9 and 10 under 35 U.S.C. § 103(a) as being unpatentable over Borsboom in view of Forg and Tang et al. (US 6,019,954). For the reasons discussed below, it is respectfully submitted that the present claims are clearly patentable over the prior art of record.

Amended independent claim 1 recites a COS treatment apparatus for a gasified gas containing COS, H₂S, H₂O, O₂, and CO. The COS treatment apparatus of claim 1 includes a first reactor into which the gasified gas is to be introduced, the first reactor being configured to increase an initial concentration of COS in the gas and decrease concentrations of H₂S, CO and O₂ in the gas at a gas temperature of at least 300°C. The COS treatment apparatus of claim 1 also includes a second reactor located at a downstream side of a gasified gas flow with respect to the first reactor, the second reactor being configured to decrease the increased concentration of COS in the gas passed through the first reactor to a concentration lower than the initial concentration of COS in the gas.

Claim 1 also recites that the first reactor comprises an O₂ removal catalyst for accelerating the following reaction: $2\text{H}_2\text{S} + 2\text{CO} + \text{O}_2 \rightarrow 2\text{COS} + 2\text{H}_2\text{O}$, with the O₂ removal catalyst consisting of TiO₂ and Cr₂O₃ or consisting of TiO₂ and NiO. Further, claim 1 recites that the second reactor comprises a COS conversion catalyst.

Amended independent claim 5 recites a COS treatment method for a gasified gas containing COS, H₂S, H₂O, O₂, and CO. The method of claim 5 includes increasing an initial concentration of COS in the gas and decreasing concentrations of H₂S, CO and O₂ in the gas by

using an O₂ removal catalyst consisting of TiO₂ and Cr₂O₃ or consisting of TiO₂ and NiO at a gas temperature of at least 300°C to accelerate the following reaction: $2\text{H}_2\text{S} + 2\text{CO} + \text{O}_2 \rightarrow 2\text{COS} + 2\text{H}_2\text{O}$. The method of claim 5 also includes, after the increasing of the initial concentration of COS in the gas and the decreasing of the concentrations of H₂S, CO and O₂ in the gas, decreasing the increased concentration of COS in the gas to a concentration lower than the initial concentration of COS in the gas by converting COS contained in the gas to H₂S by using a COS conversion catalyst.

Borsboom discloses a process for removing sulfur compounds from a CO containing gas. In particular, Borsboom discloses that O₂ is removed from a gasified gas by the hydrogenation of O₂ under a Co-Mo catalyst prior to the hydrolysis of COS. Borsboom also discloses that the hydrogenation of O₂ occurs in accordance with the following reaction: $0.5\text{O}_2 + \text{H}_2 \rightarrow \text{H}_2\text{O} + \text{heat}$ (Equation (6) of Borsboom).

However, as noted by the Examiner on page 3 of the Office Action, Borsboom does not disclose *an O₂ removal catalyst consisting of TiO₂ and Cr₂O₃ or consisting of TiO₂ and NiO*, as required by independent claims 1 and 5. Further, it is noted that Borsboom does not disclose or suggest that a Co-Mo catalyst is an O₂ catalyst which is *capable of accelerating the reaction of: $2\text{H}_2\text{S} + 2\text{CO} + \text{O}_2 \rightarrow 2\text{COS} + 2\text{H}_2\text{O}$* , as required by independent claims 1 and 5. In addition, it is noted that Borsboom does not disclose a first reactor configured to *increase an initial concentration of COS in the gas* and decrease concentrations of H₂S, CO and O₂ in the gas, as required by independent claim 1, and does not disclose a method which includes *increasing an initial concentration of COS in the gas and decreasing concentrations of H₂S, CO and O₂ in the gas by using an O₂ removal catalyst*, as required by independent claim 5.

Forg discloses a process for the removal of HCN from gas mixtures. In particular, Forg discloses a catalyst including TiO₂ and Cr₂O₃ for decomposing HCN and COS by hydrolysis, and for simultaneously suppressing the formation of COS from H₂S and CO₂ in the gas mixture. However, Forg does not disclose that a catalyst including TiO₂ and Cr₂O₃ is *an O₂ removal catalyst for accelerating a reaction of $2\text{H}_2\text{S} + 2\text{CO} + \text{O}_2 \rightarrow 2\text{COS} + 2\text{H}_2\text{O}$* , as required by independent claims 1 and 5.

In this regard, the Examiner cites Kettner as disclosing that it is known to use TiO₂ as a

catalyst for destroying COS and CS₂, and cites Messenger as disclosing that Cr₂O₃ exhibits a distinctive boundary between the oxidizing environment at the front of the catalyst such that the majority of the oxygen is consumed at the front end of the catalyst. On page 4 of the Office Action, the Examiner then concludes that it would have been obvious to one of ordinary skill in the art to modify the teachings of Forg with the teachings of Kettner and Messenger such that the catalyst of Forg (*i.e.*, TiO₂ and Cr₂O₃) “may be used as an O₂ removal catalyst to remove contaminants like oxygen and COS since Cr₂O₃ is effective in removing oxygen...and TiO₂ is effective in removing COS.”

However, it is noted that Forg discloses that a catalyst including TiO₂ and Cr₂O₃ decomposes HCN and COS by hydrolysis, and simultaneously suppresses the formation of COS (column 2, lines 47-49). Similarly, it is noted that Kettner also discloses that TiO₂ is used in destroying COS, and that by using TiO₂ as the catalyst, undesirable side reactions, such as the formation of COS, do not occur (column 4, lines 51-53). Thus, Forg and Kettner do not disclose or suggest using an O₂ removal catalyst consisting of TiO₂ and Cr₂O₃ in a first reactor configured to increase an initial concentration of COS in the gas, as required by independent claim 1, and do not disclose a method which includes increasing an initial concentration of COS in the gas by using an O₂ removal catalyst consisting of TiO₂ and Cr₂O₃, as required by independent claim 5, because Forg and Kettner explicitly state that using TiO₂ or a combination of TiO₂ and Cr₂O₃ as a catalyst will prevent the formation of COS. Further, by explicitly disclosing that using TiO₂ or a combination of TiO₂ and Cr₂O₃ as a catalyst will prevent the formation of COS, Forg and Kettner teach away from the inventions of independent claims 1 and 5, which require increasing the initial concentration of COS in the gas in the first reactor having the O₂ removal catalyst.

In addition, as indicated above, the Examiner cites Messenger as disclosing that Cr₂O₃ exhibits a distinctive boundary between the oxidizing environment at the front of the catalyst such that the majority of the oxygen is consumed at the front end of the catalyst. However, it is noted that Messenger does not disclose or suggest using an O₂ removal catalyst consisting of TiO₂ and Cr₂O₃ in a first reactor configured to increase an initial concentration of COS in the gas, as required by independent claim 1, and do not disclose a method which includes increasing an initial concentration of COS in the gas by using an O₂ removal catalyst consisting of TiO₂ and Cr₂O₃, as

required by independent claim 5.

Therefore, it would not have been obvious to one of ordinary skill in the art to combine the teachings of Borsboom with the catalyst of Forg as modified by the teachings of Kettner and Messenger so as to result in or render obvious the inventions of independent claims 1 and 5, because none of Borsboom, Forg, Kettner and Messenger disclose or suggest using an O₂ removal catalyst consisting of TiO₂ and Cr₂O₃ in a first reactor configured to increase an initial concentration of COS in the gas, as required by independent claim 1, or a method which includes increasing an initial concentration of COS in the gas by using an O₂ removal catalyst consisting of TiO₂ and Cr₂O₃, as required by independent claim 5, and because Forg and Kettner explicitly teach away from the inventions of claims 1 and 5, for the reasons discussed above.

Independent claim 9 recites a COS treatment apparatus for a gasified gas containing COS, H₂S, H₂O, O₂, and CO. The treatment apparatus of claim 9 includes a reactor into which the gasified gas is to be introduced, with *the reactor being configured to convert COS to H₂S in the presence of O₂*, and with the reactor comprising *a TiO₂ catalyst carrying Cr₂O₃ and BaO*. Claim 9 also recites that *the TiO₂ catalyst carrying Cr₂O₃ and BaO is an O₂ removal catalyst for accelerating the following reaction: $2H_2S + 2CO + O_2 \rightarrow 2COS + 2H_2O$, and that the TiO₂ catalyst carrying Cr₂O₃ and BaO is a COS conversion catalyst*.

Independent claim 10 recites a COS treatment method for a gasified gas containing COS, H₂S, H₂O, O₂, and CO. The method of claim 10 includes removing O₂ from the gas by *using a TiO₂ catalyst carrying Cr₂O₃ and BaO to accelerate the following reaction: $2H_2S + 2CO + O_2 \rightarrow 2COS + 2H_2O$* . The method of claim 10 also includes *simultaneously converting COS to H₂S by using the TiO₂ catalyst carrying Cr₂O₃ and BaO*.

Borsboom discloses a process for removing sulfur compounds from a CO containing gas. In particular, Borsboom discloses that O₂ is removed from a gasified gas by the hydrogenation of O₂ under a Co-Mo catalyst prior to the hydrolysis of COS. Borsboom also discloses that the hydrogenation of O₂ occurs in accordance with the following reaction: $0.5O_2 + H_2 \rightarrow H_2O + \text{heat}$ (Equation (6) of Borsboom).

However, as noted by the Examiner on pages 7 and 9 of the Office Action, Borsboom does

not disclose a reactor comprising a TiO_2 catalyst carrying Cr_2O_3 and BaO , and that the TiO_2 catalyst carrying Cr_2O_3 and BaO is an O_2 removal catalyst and a COS conversion catalyst, as required by independent claim 9, and does not disclose a method which includes removing O_2 from the gas by using a TiO_2 catalyst carrying Cr_2O_3 and BaO to accelerate the following reaction: $2\text{H}_2\text{S} + 2\text{CO} + \text{O}_2 \rightarrow 2\text{COS} + 2\text{H}_2\text{O}$, and simultaneously converting COS to H_2S by using the TiO_2 catalyst carrying Cr_2O_3 and BaO , as required by independent claim 10.

In this regard, as indicated above, Borsboom discloses that COS is converted to H_2S after the O_2 is removed from the gasified gas, and therefore Borsboom does not disclose a reactor configured to convert COS to H_2S in the presence of O_2 , as required by independent claim 9, and does not disclose a method which includes removing O_2 from the gas by using a TiO_2 catalyst carrying Cr_2O_3 and BaO and simultaneously converting COS to H_2S by using the TiO_2 catalyst carrying Cr_2O_3 and BaO , as required by independent claim 10.

Tang discloses catalysts for the conversion of carbon monoxide with steam into carbon dioxide and hydrogen. In particular, Tang discloses a catalyst which includes a carrier having TiO_2 and at least one catalytically active metal compound selected from the group consisting of oxides and sulfides of Co, Ni, Mo and W. On pages 8 and 9 of the Office Action, the Examiner asserts that it would have been obvious to one of ordinary skill in the art to modify the O_2 removal catalyst of Borsboom to be a TiO_2 catalyst carrying the Co-Mo catalyst of Borsboom in order to improve the conversion of carbon monoxide with steam into carbon dioxide and hydrogen.

As indicated above, Forg discloses a process for the removal of HCN from gas mixtures. In particular, Forg discloses a catalyst including TiO_2 and Cr_2O_3 for decomposing HCN and COS by hydrolysis. On pages 8 and 10 of the Office Action, the Examiner asserts that it would have been obvious to one of ordinary skill in the art to modify the combined teachings of Borsboom and Tang to result in a TiO_2 catalyst carrying Cr_2O_3 and BaO , as required by independent claims 9 and 10.

However, it is noted that the Tang and Forg references do not disclose a reactor configured to convert COS to H_2S in the presence of O_2 , as required by independent claim 9, and do not disclose a method which includes removing O_2 from the gas by using a TiO_2 catalyst carrying Cr_2O_3 and BaO and simultaneously converting COS to H_2S by using the TiO_2 catalyst carrying

Cr₂O₃ and BaO, as required by independent claim 10. As indicated above, Borsboom also does not disclose a reactor configured to convert COS to H₂S in the presence of O₂, as required by independent claim 9, and do not disclose a method which includes removing O₂ from the gas by using a TiO₂ catalyst carrying Cr₂O₃ and BaO and simultaneously converting COS to H₂S by using the TiO₂ catalyst carrying Cr₂O₃ and BaO, as required by independent claim 10.

Accordingly, as none of the Borsboom, Tang and Forg references discloses a reactor configured to convert COS to H₂S in the presence of O₂, as required by independent claim 9, and a method which includes removing O₂ from the gas by using a TiO₂ catalyst carrying Cr₂O₃ and BaO and simultaneously converting COS to H₂S by using the TiO₂ catalyst carrying Cr₂O₃ and BaO, as required by independent claim 10, it is respectfully submitted that the combination of the Borsboom, Tang and Forg references does not disclose or suggest a reactor configured to convert COS to H₂S in the presence of O₂, as required by independent claim 9, and a method which includes removing O₂ from the gas by using a TiO₂ catalyst carrying Cr₂O₃ and BaO and simultaneously converting COS to H₂S by using the TiO₂ catalyst carrying Cr₂O₃ and BaO, as required by independent claim 10.

Furthermore, Borsboom discloses that it is problematic for O₂ to be present in the supply gas when hydrolyzing COS. Thus, Borsboom discloses a first stage in which the O₂ is removed from the supply gas, and a second stage in which the COS is then hydrolyzed (column 2, lines 40-47). Accordingly, as Borsboom discloses that COS is converted to H₂S after the O₂ is removed from the supply gas, Borsboom teaches away from a reactor configured to convert COS to H₂S in the presence of O₂, as required by independent claim 9, as well as a method which includes removing O₂ from the gas by using a TiO₂ catalyst carrying Cr₂O₃ and BaO and simultaneously converting COS to H₂S by using the TiO₂ catalyst carrying Cr₂O₃ and BaO, as required by independent claim 10.

Therefore, for the reasons presented above, it is believed apparent that the present invention as recited in independent claims 9 and 10 is not disclosed or suggested by the Borsboom reference, the Tang reference and the Forg reference taken either individually or in combination. Accordingly, a person having ordinary skill in the art would clearly not have modified the Borsboom reference in view of the Tang reference and the Forg reference in such a

manner as to result in or otherwise render obvious the present invention of independent claims 9 and 10.

Therefore, it is respectfully submitted that independent claims 1, 5, 9 and 10, as well as claims 4 and 8 which depend therefrom, are clearly allowable over the prior art of record.

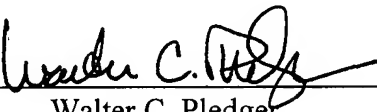
In view of the foregoing amendments and remarks, it is respectfully submitted that the present application is clearly in condition for allowance. An early notice to that effect is respectfully solicited.

If, after reviewing this Amendment, the Examiner feels there are any issues remaining which must be resolved before the application can be passed to issue, the Examiner is respectfully requested to contact the undersigned by telephone in order to resolve such issues.

The Commissioner is authorized to charge any deficiency or to credit any overpayment associated with this communication to Deposit Account No. 23-0975, with the EXCEPTION of deficiencies in fees for multiple dependent claims in new applications.

Respectfully submitted,

Masahiro HARADA et al.

By: 
Walter C. Pledger
Registration No. 55,540
Attorney for Applicants

WCP/lkd
Washington, D.C. 20005-1503
Telephone (202) 721-8200
Facsimile (202) 721-8250
July 24, 2009